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SF Dept. of City Planning

MEMORANDUM

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TO: Members of the Public

FROM: Rudolf Nothenberg, Chief Administrative Officer

5/S

1/5 indings on Unreinforced Masonry Buildings (UMBs)

Administrative Officer (CAO) is responsible for the lations to the Board of Supervisors regarding ldings. The goal is a package of legislation which ety of these buildings while avoiding undue ccupants.

f developing these recommendations, the CAO's Office rtment of City Planning to produce two studies: an ort (EIR) and a Socio-economic study.

preliminary findings describes some of what has been te. It is intended as a progress report, and no taken on it. The information contained in this be used in the EIR and Socio-economic impact reports alyze various UMB program options.

e subject of hearings before the Planning Commission EIR, incorporating public comments, will be before ll. It is anticipated that the Board of Supervisors will hear testimony on a proposed program by the end of 1990.

Your interest and participation in the crafting of the City's UMB program is very much appreciated.

Attachment

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February 27, 1990

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MEMORANDUM

TO: CAO's UMB Task Force and Interested Parties

FROM: Paul Deutsch, Project Manager, UMB Studies

RE: Summary of Preliminary Findings to Date, Studies of UMB Program Alternatives

PURPOSE OF THIS DOCUMENT

This document is intended as a summary report of information gained to date about unreinforced masonry buildings (UMBs) in San Francisco, costs to seismically retrofit them to various levels of strengthening, descriptions of such seismic retrofit work, and their expected performance in earthquakes with and without strengthening. The purpose of presenting this information at this time is to respond to intensive public inquiry for the most current and complete information available as input to the public discussion of how best to reduce seismic hazards from these buildings.

THE INFORMATION CONTAINED HEREIN IS PRELIMINARY AND SUBJECT TO CHANGE. However, it is unlikely that the information will change drastically prior to publication of the UMB studies.

BACKGROUND

The City of San Francisco is in the process of considering alternative programs to reduce the earthquake-related life safety hazard posed by the approximately 2000 privately-owned unreinforced masonry buildings (UMBs) that are located in the City. The San Francisco UMBs are brick buildings that were built before 1952, most before 1924. The City's goal is to define a program that would increase life safety (such as by making UMBs more resistant to certain types of earthquake damage) without causing unavoidable hardship (in terms of cost and disruption) on the owners, occupants and other users of these buildings.

In 1988, a United States Geological Survey (U.S.G.S.) working group estimated that there is a 50% probability that a major earthquake--larger than Richter Magnitude (R) 7.0--will occur on the northern San Andreas or Hayward fault (located 7-9 miles from downtown San Francisco) during the next 30 years--before the year 2018. There is also a 20% probability that a R 7.0 earthquake will occur in the San Francisco Bay area within the next 10 years--by the year 1998. An expert panel has been convened to evaluate how the occurence of the Loma Prieta earthquake of October 1989 may have affected these probabilities. Their findings may be available in April 1990. It is expected that their findings will confirm or raise these probabilities.

In an earthquake, deaths and major injuries are caused primarily from the complete or partial failure of existing structures. UMBs in particular have performed poorly in every damaging California earthquake. Although not all UMBs will collapse in a significant earthquake, a large number of them will have some degree of life-threatening failure, due either to partial or total collapse, or due to brick walls falling out onto open spaces. Even a relatively small one-story UMB, 25 by 75 feet, contains about 40,000 bricks, a fraction of which could seriously injure or kill a person unfortunate enough to be in their way.

Recognizing both the impending earthquake threat and the danger posed by unreinforced masonry buildings, the Mayor of San Francisco directed the Chief Administrative Officer (CAO) to recommend a program to improve the earthquake safety of the privately owned UMBs in San Francisco. In addition, the City's Bureau of Building Inspection (BBI) identified a working list of approximately 2080 UMBs and, in 1987, notified the building owners that their buildings were considered to be of unreinforced masonry construction.

In recognition of the UMB hazard and in accordance with recommendations by the City's UMB Task Force and Citizens' Advisory Committee, the CAO requested the Department of City Planning (DCP) to study the social, economic and environmental impacts of a possible City requirement to upgrade the ability of UMBs to withstand earthquake-related ground shaking. The Department of City Planning will be presenting this information in the form of an environmental impact report (EIR) and a socio-economic impact report. The Draft EIR and socio-economic report are scheduled for release by June 1990. Following a public comment period, which will include public hearings, the EIR will be finalized for release and certification by the City Planning Commission in November 1990. At such time, action could be taken on a program by the Board of Supervisors.

Over the past year, the Department's UMB Team has assembled a considerable amount of information which can benefit the Board of Supervisors, the UMB Task Force, the Citizens' Advisory Committee, UMB owners, and the general public as input to the public discussion on this issue. Therefore, in advance of the final City Planning reports, we have decided to prepare this summary even though THE INFORMATION CONTAINED HEREIN IS PRELIMINARY AND SUBJECT TO CHANGE. However, it is unlikely that the information will change drastically prior to publication of the UMB studies.

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PROFILE OF SAN FRANCISCO UNREINFORCED MASONRY BUILDINGS

Number

San Francisco's building stock contains approximately 2,000 unreinforced masonry buildings (UMBs). On December 28, 1989, a list containing 2028 buildings was transmitted from the City Department of Public Works to the State in partial compliance with requirements of SB547, the law requiring inventory, reporting, and a hazard mitigation program for unreinforced masonry buildings in seismically active areas of California. The UMB list is a working list, subject to addition and deletion of buildings as better information becomes available. For purposes of program analysis, the Department of City Planning has further studied the UMB list and developed a list for analysis purposes consisting of 2007 buildings. All of the numbers in this report and the forthcoming studies will be based on 2007 buildings. Any program adopted by the City would likely affect a greater or smaller number of buildings, and a few different buildings, than the 2007 studied. (For instance, some UMBs have been demolished due to damage sustained in the October 1989 Loma Prieta earthquake.) However, the general information, analysis, and conclusions should not be substantively different on a program level.

Location

San Francisco's UMBs are concentrated in the northeastern portion of the City, particularly in the Downtown, North of Market (Tenderloin), South of Market, Chinatown, and Bush Street corridor (southern Nob Hill) areas. Lesser concentrations occur in the Van Ness Avenue/Polk Street corridor, the Mission district, and the east side of Potrero Hill. Figure 1 depicts the General Distribution of UMBs in San Francisco, based on study areas defined for UMB study purposes. Table 1 also indicates the distribution of UMBs.

(PRELIMINARY DRAFT) TABLE 1
DISTRIBUTION OF UMBS IN SAN FRANCISCO STUDY AREAS

Study Area	Number of UMBs	% of UMBs*
1. Downtown	343	17
2. South of Market	194	10
3. South of Market Residential	114	6
4. North of Market/Civic Center	312	16
5. Bush Street Corridor	196	10
6. Van Ness/Polk	99	5
7. Chinatown	293	15
8. North Beach	50	2
9. Waterfront	36	2
10. Mission/Upper Market	136	7
11. Outlying (all other areas)	234	12

* Percentages do not total 100% due to rounding.

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Deutsch, Paul.

Memorandum to CAO's Task
Force and interested
... 1990.

General Distribution Of UMBs In San Francisco

1 Downtown (343 UMBs)
2 South of Market (194 UMBs)
3 South of Market Residential (114 UMBs)
4 North of Market / Civic Center (312 UMBs)
5 Bush Street Corridor (196 UMBs)
6 Van Ness / Polk (99 UMBs)
7 Chinatown (293 UMBs)
8 North Beach (50 UMBs)
9 Waterfront (36 UMBs)
10 Mission / Upper Market (136 UMBs)
11 Outlying (234 UMBs)

UMB Study

Figure 1

While UMBs can be found all over the city, they are highly concentrated on certain blocks. There are about 5,500 blocks in San Francisco; UMBs are located on 504 blocks, of which 234 blocks contain just one UMB. About 25% of all the UMBs are located on 24 blocks, and about one-half are located on 73 blocks.

Building Use and Demographic Characteristics

Of the UMBs studied, about 1460 (73%) contain one or more commercial enterprises. About 800 (40%) contain at least one dwelling unit, and about 300 are purely residential. Of those containing commercial uses, approximately 440 also contain residential units and are considered "mixed use" buildings. Most of the mixed use buildings are characterized by ground floor commercial uses and upper story residential uses. Table 2 summarizes UMBs by primary use.

(PRELIMINARY DRAFT) TABLE 2
DISTRIBUTION OF UMBS IN SAN FRANCISCO BY PRIMARY USE

Building Use	Number of UMBs	
Residential	784	
1-3 unit bldgs.		73
Flats w/commercial		56
Apartments w/commercial		211
Apartments w/o commercial		217
Residential hotels		145
Mixed Residential/Tourist Hotels		82
Tourist Hotels	35	
Commercial	534	
Stores, banks		504
Theaters		9
Clubs, lodges		21
Office buildings	208	
Industrial	396	
Industrial and Warehouse		324
Garages, Gas stations		72
Institutional buildings	50	
Churches or related		36
Schools or related		12
Hospitals or related		2

In all, San Francisco UMBs contain about 21,100 dwelling units, about one-half of which are apartments and one-half residential hotel units. In addition, they contain about 5270 tourist hotel units, some of which are likely used as dwellings by city residents. No specific census of UMB residents is available. It is estimated from existing data that the average nighttime population residing in UMBs is about 36,000, including about 4100 in tourist hotel units.

The dwelling units are concentrated in the North of Market (36%), Bush Street Corridor (19%) and Chinatown (15%) areas. Tourist hotel units are concentrated in the North of Market (46%), South of Market Residential (17%), Downtown (14%) and Bush Street Corridor (12%) areas.

The dwelling units in UMBs comprise a substantial portion of the low-rent units in San Francisco, and are populated by a considerably higher proportion of low-income and elderly tenants than the City as a whole. Thus, any UMB seismic hazard reduction program must take into account effects on low-rent housing stock and low-income residents.

San Francisco UMBs contain about 3950 commercial enterprises, most of which are relatively small. Any UMB seismic hazard reduction program must take into account effects on small businesses. Detailed use classifications are currently known for about 1800 of them; preliminary figures indicate that nearly one-half (about 850) are retail stores, of which about 275 are eating and drinking places; 280 (15%) provide personal or business services; 127 are industrial concerns; 116 are organizations such as civic and social associations, churches, and social services; and 71 are engaged in wholesale trade. Table 3 shows the most common types of businesses in UMBs.

(PRELIMINARY DRAFT) TABLE 3
MOST COMMON TYPES OF BUSINESSES IN S.F. UMBS

Business Type	Number in UMBs
Eating places	234
Food stores	141
Clothing stores	88
Home furnishings stores	57
Gift shops	46
Beauty parlors/barber shops	43
Drinking places	40
Miscellaneous retail stores	40
Civic & social associations	40
Auto repair shops	39
Legal services	38
Jewelry stores	37
Commercial printing	33
Religious organizations	32

Total Number of businesses for which business type is known: 1791

Age and Historical/Architectural Characteristics

Slightly over one-half of all the UMBs were built between 1906 and 1912. About 123 were constructed prior to 1906. Another one-third were built before 1924. About 170 were built between 1924 and 1952, a time by which San Francisco Building Code revisions precluded their construction.

Because of their age and the time period in which most were built, San Francisco UMBs as a class have a high degree of historical and architectural interest. Forty-two are designated City Landmarks. Many are designated as Contributory buildings in the Jackson Square Historic District, the Van Ness Avenue Plan, the Northeast Waterfront Historic District, and the proposed South End, Civic Center and Chinatown Historic Districts. In the Downtown Plan (C-3) area, 62 UMBs are Category I or II (Significant), and 117 are Category III or IV (Contributory), together representing about 42% of the 425 UMBs in the Downtown Plan area. Additional UMBs (49) are in Downtown Conservation Districts as Category V (Unrated) buildings.

About 1400 UMBs are contained in the State Historic Resources Inventory. That source indicates that sixteen UMBs are listed in the National Register of Historic Places, and another three have been determined eligible for listing. About 290 buildings have been nominated for the National Register.

Nearly three-quarters of San Francisco UMBs have been surveyed by the Foundation for San Francisco's Architectural Heritage. Heritage rates 61 UMBs as A (Highest Importance); 266 as B (Major Importance); 983 as C (Contextual Importance); and 136 as D (Minor or No Importance). The 1976 Department of City Planning architectural survey, purporting to rate the best 10% of the City's architecture (about 10,000 buildings) from a low of "0" to a high of "5", rated about 28% of the UMBs, as follows: "5" - 8 buildings; "4" - 46 buildings; "3" - 87; "2" - 155; "1" - 190; and "0" - 85 buildings.

Perhaps contrary to popular belief, the City's inventory of UMBs has not diminished substantially through demolition in the last seven years. Less than one UMB per year was demolished during this period, not counting the four that were demolished due to Loma Prieta earthquake damage. An unknown (but not large) number are being seismically strengthened each year due to S.F. Building Code requirements triggered by changes in use or additions to buildings.

Physical Characteristics

The UMB building stock is predominantly low rise, with about 68% being three stories or less; only 16% have five or more stories. In general, the greater the number of stories, the more susceptible a UMB is to damage from earthquake-related ground shaking. UMBs tend to be small to medium-sized buildings, with a median gross floor area of about 10,800 square feet and an average floor area of 18,100 square feet. Twenty percent of the UMBs are 5,000 square feet or less and less than six percent are over 50,000 square feet in size. About one-quarter are 5-10,000 square feet and another

one-quarter are 10-20,000 square feet; about one-fifth are between 20-50,000 square feet in size. Twenty-five UMBs are over 100,000 square feet. The total floor area in all UMBs studied is about 36,260,000 square feet.

The UMBs are on a variety of soil types, which differentially affect ground shaking in earthquakes. The Association of Bay Area Governments (ABAG) has computerized a map of different geologic conditions based on U.S. Geological Survey information. The soil conditions are given numbers ranging from 1 through 9, with 1 indicating "very low susceptibility" and 9 "extremely high susceptibility" to ground shaking. Table 4 presents a description of these soil condition categories and the number of UMBs in each category.

(PRELIMINARY DRAFT) TABLE 4
DISTRIBUTION OF UMBS AMONG SOIL CATEGORIES

Code	Soil Conditions	Number of UMBs
1-4	Bedrock Units	109
5	Colma Formation (older, dense sand deposits)	15
6-7	Beach and dune sand deposits and alluvium	1445
8	Filled lands adjacent to Bay Mud (possibly fill over Bay Mud in some areas)	315
9	Bay Mud (generally overlain by fill)	123

About 78% of UMBs are underlain by relatively firm soils or rock (Codes 1-7), about 16% are underlain by possibly soft soils (Code 8) and about 6% by soft soils (Code 9).

About 39% of the UMBs have a "soft story," a first floor supported on unbraced column-like elements, generally with large openings in load-bearing walls and a relative lack of internal walls. Such configurations are typical of buildings with ground floor commercial uses, whether or not upper stories contain commercial or residential uses. Soft stories tend to weaken a building's response to seismic shaking.

Shape also affects a building's seismic response, irregularly shaped buildings being generally less resistant to shaking forces. About 60% of the UMBs are square or rectangular; 26% are "notched" (rectangular buildings with

minor boundary irregularities such as stairwells or minor corner indentations; and 14% are irregular (including "L,""I,""C," and "O" shapes).

For purposes of engineering analysis, including retrofit cost and damage estimates, the 2007 UMBs analyzed were sorted into 15 prototypes based on plate size (size of ground floor), height, configuration, and use. These three basic variables account for much of the variation in cost of engineering strengthening solutions and failure modes of these buildings when subjected to shaking. Table 5 gives the prototypes and the number of UMBs in each. Figure 2 gives a sketch representative of a building for each prototype.

(PRELIMINARY DRAFT) TABLE 5
PROTOTYPES FOR ANALYSIS OF UMBS

Prototype	No. UMBs	Description
A	136	Small Area, One-Story (under 4000 sq.ft. plate size)
B	169	Large Area, One-Story (over 4000 sq.ft. plate size)
C	138	Irregular Shape, Residential
D	97	Irregular Shape, Non-Residential
E	89	Small Area, Industrial (under 5000 sq.ft. plate size)
F	143	Large Area, Industrial (over 5000 sq.ft. plate size)
G	236	2 & 3 Story, Small Area, Office & Commercial (Under 4000 sf)
H	176	2 & 3 Story, Large Area, Office & Commercial (Over 4000 sf)
I	70	Over 3 Story, Small Area, Office & Commercial (Under 4000 sf)
J	83	Over 3 Story, Large Area, Office & Commercial (Over 4000 sf)
K	162	2 & 3 Story, Small Area, Residential (Under 2500 sq.ft. plate)
L	147	2 & 3 Story, Large Area, Residential (Over 2500 sq.ft. plate)
M	139	Over 3 Story, Small Area, Residential (Under 4000 sq.ft. plate)
N	162	Over 3 Story, Large Area, Residential (Over 4000 sq.ft. plate)
O	60	Public Assembly-type

Building uses for the purpose of structural prototyping do not necessarily correspond with uses as classified for other types of analysis, such as those presented in Table 2.

RETROFIT PROJECT DESCRIPTIONS

Five alternative programs are being considered by the City to address UMB-related seismic hazards to life safety, of which three involve mandatory retrofit of UMBs to different levels of strengthening. Alternative A is "no project" (no program beyond those already in effect). Alternative B is a "voluntary retrofit" program that may require, for example, a retrofit engineering study and cost estimate for each UMB to be performed and made public. Alternative C is "Anchoring walls to floors and roof" plus measures to reduce out-of-plane wall failures. Alternative D is a proposal for the 1991 Uniform Code for Building Conservation which is similar to current practice in retrofitting buildings in Los Angeles, which has had a mandatory

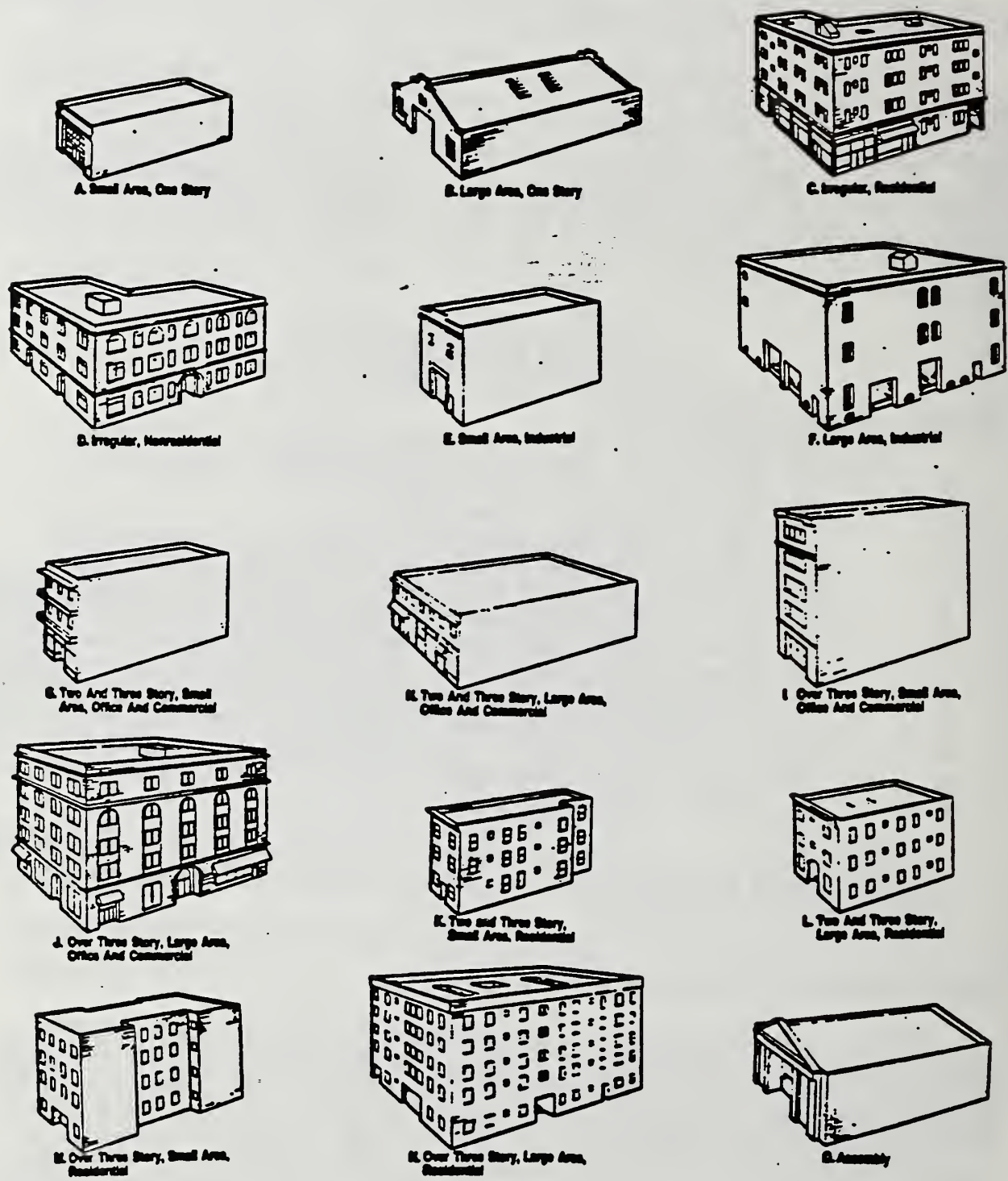
A. Small Area, One Story
B. Large Area, One Story
C. Irregular, Residential
D. Irregular, Nonresidential
E. Small Area, Industrial
F. Large Area, Industrial
G. Two And Three Story, Small Area, Office And Commercial
H. Two And Three Story, Large Area, Office And Commercial
I. Over Three Story, Small Area, Office And Commercial
J. Over Three Story, Large Area, Office And Commercial
K. Two and Three Story, Small Area, Residential
L. Two And Three Story, Large Area, Residential
M. Over Three Story, Small Area, Residential
N. Over Three Story, Large Area, Residential
O. Assembly

Figure 2 — Prototypes

UMB retrofit ordinance since 1981. Alternative E is the mandatory application of Section 104(f) of the San Francisco Building Code, seismic strengthening that is currently triggered in any building only upon substantial addition, alteration, or intensification of use.

In general, Alternatives C, D, and E in order involve increasing amounts of strengthening activities, with associated increasing costs, construction disruption and dislocation, and damage and casualty reductions. The following descriptions and costs associated with strengthening activities will vary widely on a building-by-building basis and are intended to be general in nature. The most appropriate retrofit solution for any one building will depend on its structural characteristics, general conditions, and the relative importance placed on several other project variables such as initial construction cost, occupancy and use of the building during construction, long term effects of strengthening elements on building function, aesthetics, and non-seismic improvements.

Alternative C: Wall Anchors/Reduction of Collapse Potential

Under this alternative, strengthening activities would be limited to those which anchor unreinforced masonry walls to floors and roofs, or those intended to prevent walls from collapsing perpendicular to their length ("out of plane"). Typically such work is confined to the perimeter walls, though larger buildings may have interior unreinforced masonry walls which must be treated similarly.

Retrofit projects under this alternative would generally be considered small. Projects would usually require a small temporary contractors' office, staging, and storage area. Two to three workers would be required, although several such crews may be needed for larger or more complex buildings. In general, the work required under this alternative is not too different than a local remodel. Short term, intermittent noise and disruption from construction traffic as well as presence of fine dust would be expected. If welding of structural steel is required, the general disruption level would be greater, with ventilation and heavier equipment needed. Such work can normally be avoided with careful design but will occasionally be required. Old wall and floor finishes could be difficult to match up and refinish, unless low quality finishes were considered acceptable (e.g. for an industrial building).

This level of retrofit can normally be done with occupants in place. In industrial and commercial buildings, the most disruptive work could be scheduled at night or on weekends or at other times a particular building is normally closed. Commercial uses may need to vacate areas near unreinforced masonry walls for 5-10 days to allow construction during occupancy. For residential buildings, their typically low floor to floor heights rarely require out-of-plane strengthening, and small room sizes offer opportunities to block off and seal construction areas for short periods of time during general occupancy. Noise and construction traffic would make occupancy in

adjacent rooms uncomfortable for the 5-10 days that the complete cycle of construction may take in each room. Temporary utility interruptions could occur but can be minimized with careful planning. Retrofit of residential buildings can be made considerably easier if owners accrue vacancies in advance of construction. Temporary relocations within a building can then be handled much more flexibly.

Total construction time per building varies widely but is generally proportional to building size and construction cost. For buildings with occupants in place, a general range is 5-16 weeks.

Alternative D: 1991 Uniform Code for Building Conservation

Under this alternative, which is comparable to current practice in Los Angeles, the wall anchors and possible out-of-plane strengthening required by Alternative C would have to be supplemented by possible strengthening of other building elements including diaphragms (floors and roofs) and walls themselves. A substantial increase in construction activity is generally required compared with Alternative C. Construction activities would be somewhat beyond a "remodel," and could require extensive removal of finishes, installation of plywood shear walls, and possibly installation of structural steel (particularly to brace storefronts with little or no solid wall). In some cases, new reinforced masonry or concrete walls, or shotcrete (sprayed concrete) over existing walls may be needed. Selection of a particular strengthening scheme under this alternative would be affected most by the specific requirements of occupancy during construction as well as architectural considerations. While it is always possible to keep the space occupied during construction, there may be considerable inconvenience to occupants and disruption of efficient work flow.

Construction disruption is greater than Alternative C but less than Alternative E. Installation of wall anchors would require more plaster removal and patching than Alternative C. A work area would be required for the contractor. Large items such as structural steel would be installed when delivered, though some site fitup and welding is commonly necessary. Deliveries to the typical site would include large trucks and trailers and, for short periods, cranes for structural steel installation. When steel is required, heavy components must be lifted and welding or bolting in place is required. Holes are often cut in the roof and floors to permit columns to be "dropped in." Moment frames (steel beams and columns welded at their joints) would be used extensively for the front, open facade of commercial buildings and in buildings with large or architecturally sensitive open spaces. They require a concrete grade beam, which necessitates excavation to a depth of 3-5 feet and a width of 2 feet or more across the width or partial width of the structure.

Industrial buildings usually can be retrofitted under this alternative with the least disruption, unless clean rooms are required for the particular use. Commercial buildings would have to contend with dust, noise, and often

excavation as well as security considerations. If work can be done from the roof or floor above or below, occupancy may be possible in many areas with only short interruptions. Residential buildings frequently do not require work on the walls at the upper floors since interior walls are allowed by the Code to be counted toward existing resistance to lateral shaking forces. The walls of the top floor must be extended from the ceiling to the roof to act as cross or shear walls. Walls may need to be strengthened at the lower levels. Installation of anchor bolts results in dust, debris, disruption and noise. Residential units can take several days to complete and result in temporarily dirty, drafty spaces. The same considerations of temporary utility disruptions and permitting vacancies to accrue in advance of construction work applicable to Alternative C apply to this alternative as well. Accounts of the experience in Los Angeles indicate that while this level of retrofit can be accomplished in almost all cases with occupants in place, it is extremely disruptive and unpleasant. In Los Angeles, typical residential vacancy rates are about 5%. In order to provide for work areas and greater options for staged construction, many owners allowed a vacancy of 10-12% to accrue just prior to construction. Vacancies increased to around 25-30% by the time construction finished (due not only to the unpleasantness of the construction but also the knowledge that rents would go up as retrofit costs were passed through), and ultimately recovered to about 5%.

Again, total construction time per building varies widely, depending on factors which include the amount of work needed, building size, and whether the work is done with occupants in place. Smaller projects tend to take 2-3 months, larger and more complex projects 3-6 months. With occupants in place, projects would tend to take 3-10 months.

Alternative E: San Francisco Building Code Section 104(f)

Under this alternative, a considerable number of strengthening activities could be required. In most cases, roof and floor diaghragm strengthening would be needed. In-plane strengthening would be needed for most buildings with walls over one story in height that have window or door openings, and for most solid property line walls over four stories tall. The need for these various elements in a retrofit project represents a substantial escalation in construction activity. Construction activities typically utilize structural steel or concrete and new foundations are required.

As with the other alternatives, the particular types, number, and material of strengthening elements depends on building shape and dimensions and non-structural considerations such as aesthetics, building function, or need for continuous occupancy. For example, residential and commercial buildings can seldom accept the aesthetic consequences or loss of street exposure resulting from infilled openings, but this technique can be acceptable in industrial buildings that are not considered architecturally significant. Installation of freestanding interior concrete or reinforced masonry walls is usually disruptive to the functions of industrial or commercial buildings, but might be acceptable in a residential building.

Most buildings strengthened under Section 104(f) to date in San Francisco have been done during a general remodel or change in occupancy and therefore were usually vacant. For work done with occupants in place, the construction area would have to be vacated and sealed off. Projects under this alternative would require extensive construction work for all except the smallest buildings. A 2-3,000 square foot construction staging area would typically be needed, and large construction vehicles and equipment would occasionally need to park outside the building. Structural steel, concrete, and finish materials such as lumber, steel studs, plywood, and gypsum board would need to be stored at the site or frequently delivered. Access to upper floors is important; if a freight elevator is not available, truck mounted cranes or lifts would be needed to create access through windows. Separation of construction and occupant traffic is not always possible. In-plane strengthening element placement involves heavy construction work usually requiring excavating and removing soil for foundations, and placement of reinforcing steel and concrete. In-plane elements always must penetrate the floors, which requires work on at least two levels at once and creates temporary holes in the floors which often require temporary shoring. Installation of large steel beams and "wet" processes such as installation of concrete involve difficulties because of their size and/or preparation, placement, and cleanup characteristics.

Normally this alternative would require large building areas dedicated to the contractor. Preferably a building would be vacated but it is considered feasible in most cases to phase construction vertically, two floors at a time (or horizontally if a building has wings or other natural separations). Industrial buildings generally offer the greatest options for strengthening without extensive disruption of functions. For commercial buildings, although noisy or disruptive work could be done at off hours, the kinds of retrofit activities needed are incompatible with commercial or office operations and construction phasing or building vacancy would be expected. Occupancy for residential buildings during construction would be marginal due to constant and serious disruptions. In smaller buildings that have little area in which to phase construction, temporary evacuations would be necessary. In larger buildings, large areas would have to be temporarily vacated and disruption to remaining occupants would be serious.

Duration of retrofit activities under Alternative E would typically be two months for the smaller projects, 3-4 months for medium size projects, and 6-8 months for larger projects for vacant buildings. Additional time needed to retrofit with occupants in place would be about 25-50% for industrial uses, 70-100% for commercial uses, and 100% for residential buildings.

RETROFIT COSTS

Average costs per square foot have been developed for each of the 15 prototypes representative of San Francisco UMBs, for each retrofit alternative (C, D, and E). Even within a single prototype, a wide variation in costs will occur due to individual building characteristics and priority tradeoffs to be

made by the owner (i.e. quality of finish work, whether to vacate the building, etc.). The cost estimates are intended to be accurate as an average per square foot for all buildings in a prototype and should not be taken as an estimate for any one particular building. Only a site-specific engineering design and cost estimate can give an accurate picture of true retrofit costs.

It is important to understand what the estimated costs do and do not include. The base cost includes all material, equipment, and labor with the appropriate subcontractor's markup, general conditions (including field supervision, field engineering by the contractor, superintendent's costs, and any other known contractor expenses that are not specified in the contract), general contractor's overhead and profit, bond and insurance fees, contingencies and escalation allowances necessary for a Conceptual Estimate of costs for rehabilitating and restoring a medium grade finish level to unreinforced masonry buildings as defined by the prototypes given in Table 5.

The base cost was estimated for vacant buildings and does not include cost premiums for work done with occupants in place. These premiums are separated from base costs in the following information to allow both cases to be considered. The need for cost premiums to accommodate retrofitting with as much occupation as possible would be caused by inefficient structural schemes and/or construction procedures determined by functional requirements; protection of areas adjacent to construction; off-hour work; and longer construction period creating increased general conditions costs.

Other items excluded from the cost estimates are: engineering and architectural design fees; plan checking and permit fees; utilities needed to perform construction; owner's insurance and administration cost; construction management fees; cost of money; and lost revenues to owners and businesses. Indirect costs such as tenant relocation are also not included. All of these additional cost items will be discussed in the UMB studies.

Also excluded from these calculations are cost differentials attributable to retrofitting architecturally significant or historic buildings, and costs of any concurrent remodelling or renovation apart from seismic strengthening. Both these costs will be addressed in the draft UMB studies.

Cost Premiums

Cost premiums to be applied if retrofit is done with occupants in place depend on whether the occupancy is residential, commercial, or industrial:

Group	Characteristics	Prototypes Included
Industrial	Low occupancy Few partitions, low interior finishing	Some in A and B; all of E,F
Commercial	Cyclic occupancy Moderate partitions and interior finishing	Some in A and B; all of D,G,H,I,O
Residential	Continuous Occupancy Many partitions, high interior finishing	Some in A and B; all of C,K,L,M,N

Cost premiums to accommodate occupancy while retrofit work takes place are estimated as follows:

	Alternative C	Alternative D	Alternative E
Industrial Group	15-25%	15-25%	15-25%
Commercial Group	30-40%	30-40%	30-40%
Residential Group	40-50%	30-40%	30-40%

Table 6 presents, by prototype, base costs for the three retrofit alternatives.

(PRELIMINARY DRAFT) TABLE 6
UMB ALTERNATIVE RETROFIT PROJECT BASE COSTS PER SQUARE FOOT BY PROTOTYPE

All costs in December 1989 dollars per square foot

This table presents average costs/sq.ft. by building prototype for retrofitting and restoring a moderate level of finish to vacant UMBs. Actual costs will vary considerably from building to building.

Prototype/Description*	Alternative C	Alternative D	Alternative E
A - small, 1 story	$9.84	$10.71	$14.15
B - large, 1 story	5.59	7.87	9.30
C - irreg., Resid.	5.04	8.18	13.72
D - irreg., Non-Resid.	5.68	7.95	14.67
E - small, Indust.	9.21	10.90	15.26
F - large, Indust.	4.21	7.57	9.48
G - sm., 2-3 story, Off/Comm	12.31	13.66	18.44
H - lg., 2-3 story, Off/Comm	5.55	8.23	11.18
I - sm., 4+ story, Off/Comm	9.05	15.17	22.14
J - lg., 4+ story, Off/Comm	4.59	8.63	14.45
K - sm., 2-3 story, Resid.	11.80	12.95	18.55
L - lg., 2-3 story, Resid.	6.84	8.76	12.51
M - sm., 4+ story, Resid.	6.55	15.83	18.81
N - lg., 4+ story, Resid.	4.23	9.68	16.50
O - assembly	8.01	11.01	15.86
Overall weighted average	5.75	9.37	13.93

* Refer to Table 5 for more prototype description details.

Table 7 presents, by prototype and summed for all UMBs, total base costs for the three retrofit alternatives; that is, the average cost per square foot multiplied by the total number of square feet in all the buildings. The grand total, when adjusted for cost premiums for occupants in place and excluded costs, represents an approximation of the direct costs of the basic alternatives less premiums for historic building retrofit work.

(PRELIMINARY DRAFT) TABLE 7
UMB ALTERNATIVE RETROFIT PROJECT COSTS FOR ALL BUILDINGS, BY PROTOTYPE FOR VACANT BUILDINGS

All costs in December 1989 dollars

This table presents estimated costs by building prototype for retrofitting and restoring a moderate level of finish to vacant UMBs.

Prototype/Description*	Alternative C	Alternative D	Alternative E
A - small, 1 story	$ 3,251,000	$ 3,539,000	$ 4,675,000
B - large, 1 story	9,960,000	14,023,000	16,571,000
C - irreg., Resid.	18,458,000	29,958,000	50,248,000
D - irreg., Non-Resid.	18,219,000	25,500,000	47,055,000
E - small, Indust.	6,216,000	7,357,000	10,299,000
F - large, Indust.	23,429,000	42,128,000	52,757,000
G - sm., 2-3 story, Off/Comm	16,380,000	18,176,000	24,537,000
H - lg., 2-3 story, Off/Comm	21,231,000	31,483,000	42,768,000
I - sm., 4+ story, Off/Comm	7,666,000	12,850,000	18,754,000
J - lg., 4+ story, Off/Comm	17,130,000	32,208,000	53,928,000
K - sm., 2-3 story, Resid.	8,252,000	9,056,000	12,973,000
L - lg., 2-3 story, Resid.	13,291,000	17,022,000	24,309,000
M - sm., 4+ story, Resid.	11,660,000	28,179,000	33,483,000
N - lg., 4+ story, Resid.	24,173,000	55,319,000	94,293,000
O - assembly	9,333,000	12,828,000	18,479,000
TOTALS	$208,649,000	$339,626,000	505,129,000.
WITH OCCUPANTS IN PLACE...	$274-294 Million	$433-467 Million	$646-696 Million

* Refer to Table 5 for more prototype description details.

Table 7 indicates that the total cost to retrofit all UMBs to retrofit Alternative D is about 1.6 times as costly as Alternative C, and Alternative E is about 2.4 times as costly as C and about 1.5 times as costly as D. Among prototypes and for any one building these cost differentials vary widely.

Because of the many mixed use buildings distributed among prototypes, none of the prototypes is purely residential vs. commercial vs. industrial. Therefore, an estimate of the total program cost by use can only be approximate. With that limitation in mind, it is estimated that retrofit costs with building occupants in place--exclusive of premiums for historic buildings, indirect costs, and excluded costs discussed previously--would be as presented in Table 8, next page.

(PRELIMINARY DRAFT) TABLE 8
UMB ALTERNATIVE RETROFIT PROJECT COSTS FOR ALL BUILDINGS, BY USE
FOR RETROFIT WORK WITH OCCUPANTS IN PLACE

All costs in December 1989 dollars

This table presents estimated costs by general building use for retrofitting and restoring a moderate level of finish to UMBs with occupants in place whenever possible.

	Alternative C	Alternative D	Alternative E
Residential buildings	$107-114 Million	$182-196 Million	$281-302 Million
Average per building	$139-148,000	$236-254,000	$364-391,000
Comm./Office buildings	$125-135 Million	$184-198 Million	$280-302 Million
Average per building	$146-158,000	$215-232,000	$327-353,000
Industrial buildings	$ 42-45 Million	$ 67-73 Million	$ 85-92 Million
Average per building	$111-118,000	$176-192,000	$224-242,000

The average costs per building in this table will vary considerably by prototype and from building to building.

Dividing the total base cost to retrofit all buildings in a prototype by the number of buildings in the prototype yields an approximation of the average base cost of retrofitting a building in that prototype. These figures are presented for each alternative in Table 9, next page.

DAMAGE AND CASUALTIES

The damage to San Francisco UMBs and resulting deaths and major (hospitalized) injuries have been estimated for existing, unstrengthened UMBs and for UMBs strengthened to each of the three retrofit alternatives. The estimates were made by Rutherford & Chekene, structural engineering consultants for this project, and are based on the UMB prototypes. Also taken into account are such factors as soils, story heights, parapet bracing, general construction quality of San Francisco UMBs, and adjacencies (whether another building is adjacent to the UMB, whether it is also a UMB or not, whether it is taller or shorter than the UMB). Building and street occupancies were estimated for different times of day using best available information. Details of assumptions, sources and methodology will be available when the draft UMB studies are released.

Damage and casualty estimates were calculated in two different ways, as annual expected losses and under specific earthquake scenarios. The annual expected loss calculations take into account the annual probability of all

(PRELIMINARY DRAFT) TABLE 9
AVERAGE RETROFIT COST PER BUILDING, BY PROTOTYPE

All costs in December 1989 dollars

This table presents estimated average costs per building, by prototype, for retrofitting and restoring a moderate level of finish to vacant UMBs.

Actual costs will vary considerably from building to building.

Prototype/Description*	# UMBs	Average Cost Per UMB for Alternative: C	D	E
A - small, 1 story	136	$24,000	$26,000	$34,000
B - large, 1 story	169	59,000	83,000	98,000
C - irreg., Resid.	138	134,000	217,000	364,000
D - irreg., Non-Resid.	97	188,000	263,000	485,000
E - small, Indust.	89	70,000	83,000	116,000
F - large, Indust.	143	164,000	295,000	369,000
G - sm., 2-3 story, Off/Comm	236	69,000	77,000	104,000
H - lg., 2-3 story, Off/Comm	176	121,000	179,000	243,000
I - sm., 4+ story, Off/Comm.	70	110,000	184,000	268,000
J - lg., 4+ story, Off/Comm.	83	206,000	388,000	650,000
K - sm., 2-3 story, Resid.	162	51,000	56,000	80,000
L - lg., 2-3 story, Resid.	147	90,000	116,000	165,000
M - sm., 4+ story, Resid.	139	84,000	203,000	241,000
N - lg., 4+ story, Resid.	162	149,000	341,000	582,000
O - assembly	60	156,000	214,000	308,000
Total/Weighted Average	2007	104,000	169,000	252,000

For retrofit work done with occupants in place, the cost premiums given on page 16 must be added to all the above costs.

* Refer to Table 5 for more prototype description details.

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earthquakes of all likely magnitudes which could affect San Francisco. The resulting numbers (Table 10) are better used for program planning purposes than those for the scenario earthquakes.

The damage estimates are expressed both as a percentage of building replacement cost and in dollars. Casualties are expressed as number of fatalities and number of hospitalized injuries. Also given is the area and number of buildings expected to receive greater than 50% damage (40% for unstrengthened buildings) and which would therefore be likely to be demolished or not functional for a time considerably longer than normal repair time.

(PRELIMINARY DRAFT) TABLE 10
ANNUAL EXPECTED UMB EARTHQUAKE LOSSES, UMB PROGRAM ALTERNATIVES

All numbers in this table represent the statistical average expected losses in one year from all potential earthquakes affecting S.F.

The expected losses in X years equals approximately X times the figures in this table.

Alternative	Property Loss in %[1]	Property Loss in $1,000	Deaths[2]	Hospital Injuries	Likely Demolished Sq.Ft.[3]	Likely Demolished (# Bldgs)
A- No Retrofit	1.6%	$46,800	12.6	50.7	420,000	(23.2)
C- Wall anchors	1.1%	30,900	6.2	25.0	126,100	(7.0)
D- UCBC (L.A.)	0.7%	20,700	2.2	8.8	50,000	(2.8)
E- Sec. 104(f)	0.6%	15,700	1.6	6.3	31,100	(1.7)

[1] Property loss expressed as a percentage of UMB stock replacement cost.

[2] Includes all UMB-related deaths, both inside and outside the buildings.

[3] The area of UMBs expected to receive damage greater than 40% of replacement cost (50% for strengthened buildings) and therefore considered likely to be demolished or non-functional for considerably longer than normal repair time. Dividing the area as given in square feet by the average UMB size yields a very rough estimate of the number of buildings in this category, given in parentheses.

Table 10 indicates that, for example, in any ten year period, statistically expected earthquake losses in UMBs if none are strengthened would total nearly one-half billion dollars, and that 126 fatalities and 507 hospital injuries would be expected. About 232 buildings could be lost to demolition or rendered unusable for extended periods of time. Of course, these numbers represent statistical averages based on all known risks from all known earthquake faults affecting San Francisco. The actual losses in any ten year period or from any one earthquake would be higher or lower than statistical expectations.

Table 10 also shows that, compared with existing unstrengthened buildings, retrofitting all UMBs to the Alternative C level would result in about one-half the deaths and injuries and two-thirds the property damage; Alternative D would result in about one-sixth the deaths and injuries and less than one-half the damage; and Alternative E would result in about one-eighth the deaths and injuries and one-third the damage.

Put another way, Table 10 shows that, compared with unstrengthened buildings, Alternative C would save about 6 lives annually, Alternative D would save 4 more (10 more than not strengthening), and Alternative E less than one more life annually (11 more than not strengthening).

To understand building performance in a given earthquake, loss calculations were performed for scenario earthquakes: a magnitude 7.0 on the Hayward Fault at 3:00 a.m. and 3:00 p.m., and for a magnitude 8.3 on the northern San Andreas Fault (comparable to the 1906 earthquake) at 5:30 p.m. The results are given in Tables 11, 12, and 13.

(PRELIMINARY DRAFT) TABLE 11
EXPECTED UMB EARTHQUAKE LOSSES, UMB PROGRAM ALTERNATIVES
Magnitude 7.0 Earthquake, Hayward Fault, 3:00 p.m.

Alternative	Property Loss in %[1]	Property Loss in $1,000	Deaths[2]	Hospital Injuries	Likely Demolished Sq.Ft.[3]	Likely Demolished (# Bldgs)
A- No Retrofit	29%	$837,000	438	1751	9,230,000	(510)
C- Wall anchors	22%	619,000	203	813	1,920,000	(106)
D- UCBC (L.A.)	14%	405,000	44	176	430,000	(24)
E- Sec. 104(f)	10%	297,000	23	92	150,000	(8)

[1] Property loss expressed as a percentage of UMB stock replacement cost.

[2] Includes all UMB-related deaths, both inside and outside the buildings.

[3] The area of UMBs expected to receive damage greater than 40% of replacement cost (50% for strengthened buildings) and therefore considered likely to be demolished or non-functional for considerably longer than normal repair time. Dividing the area as given in square feet by the average UMB size yields a very rough estimate of the number of buildings in this category, given in parentheses.

As Tables 11 and 12 indicate, expected UMB-related deaths and injuries in a 7.0 earthquake on the Hayward Fault depend on the time of day that the event will occur. Casualties are much lower at night because considerably less people are in the office, commercial, and assembly buildings and very few people are on the street. Building damage, of course, would be the same.

(PRELIMINARY DRAFT) TABLE 12
EXPECTED UMB EARTHQUAKE LOSSES, UMB PROGRAM ALTERNATIVES
Magnitude 7.0 Earthquake, Hayward Fault, 3:00 a.m.

Alternative	Property Loss in %[1]	Property Loss in $1,000	Deaths[2]	Hospital Injuries	Likely Demolished Sq.Ft.[3]	Likely Demolished (# Bldgs)
A- No Retrofit	29%	$837,000	61	242	9,230,000	(510)
C- Wall anchors	22%	619,000	25	101	1,920,000	(106)
D- UCBC (L.A.)	14%	405,000	8	32	430,000	(24)
E- Sec. 104(f)	10%	297,000	5	21	150,000	(8)

1 Property loss expressed as a percentage of UMB stock replacement cost.

2 Includes all UMB-related deaths, both inside and outside the buildings.

3 The area of UMBs expected to receive damage greater than 40% of replacement cost (50% for strengthened buildings) and therefore considered likely to be demolished or non-functional for considerably longer than normal repair time. Dividing the area as given in square feet by the average UMB size yields a very rough estimate of the number of buildings in this category, given in parentheses.

(PRELIMINARY DRAFT) TABLE 13
EXPECTED UMB EARTHQUAKE LOSSES, UMB PROGRAM ALTERNATIVES
Magnitude 8.3 Earthquake, San Andreas Fault North, 5:30 p.m.

Alternative	Property Loss in %[1]	Property Loss in $1,000	Deaths[2]	Hospital Injuries	Likely Demolished Sq.Ft.[3]	Likely Demolished (# Bldgs)
A- No Retrofit	42%	$1,196,000	1275	5100	18,480,000	(1021)
C- Wall anchors	33%	941,000	713	2852	5,810,000	(321)
D- UCBC (L.A.)	22%	643,000	190	758	1,680,000	(93)
E- Sec. 104(f)	18%	520,000	116	462	830,000	(46)

1 Property loss expressed as a percentage of UMB stock replacement cost.

2 Includes all UMB-related deaths, both inside and outside the buildings.

3 The area of UMBs expected to receive damage greater than 40% of replacement cost (50% for strengthened buildings) and therefore considered likely to be demolished or non-functional for considerably longer than normal repair time. Dividing the area as given in square feet by the average UMB size yields a very rough estimate of the number of buildings in this category, given in parentheses.

SOURCES OF INFORMATION

Information regarding the unreinforced masonry buildings in San Francisco has been obtained from the Bureau of Building Inspection, Department of City Planning, Assessor's Office, and other City agency records; Sanborn Fire Insurance Maps. Demographic information has been obtained from Census data, community organizations, and Pacific Gas & Electric. Cost, damage, and casualty estimates have been performed by Rutherford & Chekene, engineering consultants for the UMB studies.

ADDITIONAL INFORMATION TO BE PROVIDED

Information on what retrofit work entails, costs to retrofit, and resulting performance of UMBs is critical to discussion of a reasonable, effective seismic hazard reduction program for these buildings. Equally important is information on the ability of UMB owners and their commercial and residential tenants to pay for retrofit work, types and availability of potential resources to pay for retrofit work, possible incentives to retrofit, effects of retrofit alternatives on building occupants, neighborhoods, and architectural/historical resources, and potential owner decisions when faced with a mandatory retrofit requirement, including possible demolition and resultant physical and socioeconomic effects. Also important are the effects of program decisions regarding priorities for retrofit and total program length. These issues and others will be addressed in the forthcoming UMB studies.

For now, it is hoped that the information contained in this report will be useful to inform the public discussion on the retrofit issue.

If you would like to be involved in this discussion and the decision-making process, you should contact David Prowler, Assistant to the Chief Administrative Officer, at 558-6280. If you would like to be notified when the draft UMB studies become available, please call 558-6395, and notify the secretary that you would like to leave your name and mailing address to be notified of the UMB studies. If you would like to discuss the studies, please call Paul Deutsch at 558-6383.